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2009

Simulating Decision Support Systems: A Laboratory Experiment

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ABSTRACT

This study implements decision support systems (DSS) in a business simulation game. Fifty-Eight companies, consisting of about 300 senior graduate students participating in a business game, developed DSS and reported on the systems developed. We later evaluated a number of variables related to their DSS: use of systems, contribution of systems, and user satisfaction. Our findings validate the use of the simulation exercise as a practical tool for measuring DSS effectiveness.

Keywords

Decision Support Systems, Simulations, Business Games

INTRODUCTION

Information systems studies have used a variety of instruments to measure information systems (IS) effectiveness (see, for example, Bharati and Chaudhury, 2004; DeLone and McLean, 2003; Reinig, 2003; Sharda et al., 1988; Srinivasan, 1985). The focus of this study is decision support systems (DSS). DSS is used to provide computer-based support to decision makers involved in solving semi-structured and unstructured problems. Studies show that DSS are effective when both the user and the system work toward the cooperative purpose of improving decision-making; that is, the information needs of the users (the decision makers) are appropriately supported by the DSS (Khazanchi, 1991). Consequently, the question of effectiveness is extremely important.

This study investigates DSS and the factors that affect their effectiveness. We use a game simulation method for this research, where the game becomes the platform for the participants to experience DSS. We follow an approach akin to that of Ein-Dor and Segev (1984) and of Ben-Zvi (2007) in their business game studies. The paper is organized as follows: First, we review business game simulations. Then, we describe the employed game and set the study's hypotheses. Next, we examine the implementation of DSS in the proposed game and analyze related variables. Finally, we discuss the applicability of this study and draw conclusions.

BUSINESS SIMULATION GAMES

A general-purpose business game is, by definition, a highly complex man-made environment. Business simulation games are occasionally described in the literature. In 2001, a special issue of *Simulation & Gaming* (Volume 32, no. 4, 2001) was dedicated to the state of the art and science of simulation and gaming. Wolfe and Crookall (1998) assessed the state of simulation and gaming as a scientific discipline.

The objective of a business game is to offer students the opportunity to learn by doing in as authentic a management situation as possible and to engage them in a simulated experience of the real world (e.g., Garris et al., 2002; Martin, 2000). In most cases; this makes the business game impractical for controlled experimentation. However, it enhances the characteristics of the game as a simulation of real life, and behavior observed may be generalized to reality (e.g., Lainema and Makkonen, 2003).

In 2003, a special issue of *Communications of the ACM*, named "A Game Experience in Every Application", was dedicated to simulation games in diverse applications. Furthermore, over the years, researchers have reported the extent of usage of simulation games in academe and business (e.g., Ben-Zvi and Carton, 2007; Courtney and Paradice, 1993; DeLone and McLean, 2003; Dickson et al., 1977; Faria, 1987, 1998). However, simulations created especially for research purposes are

usually oversimplified and less realistic. Most involve only a single decision maker interacting with the computer program facing rather uncomplicated structured problems in a relatively restricted time period. For example, Brozik and Zapalska (2000) explored the "Restaurant Game", a single-period simulation that provides students the opportunity to plan and implement a strategy in a competitive environment. When playing the game, the game instructor can demonstrate how mathematical modeling leads to an optimal solution.

HYPOTHESES AND METHODOLOGY

The Game Employed

This study employs the international version of a widely used business game developed in the United States and commonly known as the International Operations Simulation Mark/2000 (hereafter INTOPIA™). The prime purpose of this business game is to increase students' understanding of strategic management of international operations in general and those of the multinational corporation in particular. Furthermore, the game is designed to yield substantial payoff in general management training. It forces participants into a stream of truly entrepreneurial top management decisions of business philosophy and a search for logic and synergy in the business objectives-strategy-implementation sequence (Thorelli et al., 1995). We use the game to establish a managerial decision-making context: The game involves the students in the executive process, motivates their need for decision-making aids and forces them to adopt a managerial viewpoint associated with MIS and DSS.

The game is played for a full semester and is operated by up to 25 competing companies; the markets are similar to the markets in the United States (US), the European Union (EU) and Brazil, wherein each company can operate a local branch. "Operated" is a broad concept and covers any one or any combination of the functions of manufacturing, marketing of one's own products or selling to overseas distributors, serving as a distributor or a subcontractor, exporting, importing, financing and licensing. The incoming participants enter a "going concern" with 4 periods of simulated history and play 6 to 10 additional game-periods. The task of the companies is to make decisions which will guide operations (simulated by the easy to realize computerized system) in the forthcoming period and which will affect operations in subsequent periods.

Decisions are made once a week and are e-mailed to the game administrator to be fed to the computer program. After the program runs the data, it generates company outputs that include financial reports (e.g., a balance sheet, an income statement), production reports and market researches. These outputs are then e-mailed to the companies and are used for decision making in sequential periods. The length of the each time period simulated is usually referred to as one year. Dozens of decisions, covering the entire range of a typical business, are required of a company in each period. The decision-making process is based on an analysis of the company's history as presented to players at the beginning of the game, interaction with other companies and external agents of the game (e.g., bankers, board of directors), and the constraints stated in the player's manual (e.g., procedures for production, types of marketing channels available). Usually, each student is taking an executive role and is responsible for the decision making in his/her expertise domain and for the decision coordination with his/her colleagues in adjacent areas (e.g., the chief operations officer makes operation decisions and coordinates them with both the chief financial officer and the chief marketing officer).

The performance of a company in each period is affected by its past decisions and performance, the current decisions, simulated customer behavior, and the competition – the other companies in the industry.

The game has become highly realistic as a result of the efforts invested in it to simulate the total environment. Students participating in the game immerse themselves in this artificially created world. They form small teams, allocate responsibilities for specific functions, and work to achieve common goals which they themselves define. While each of them becomes a specialist in his or her function, a joint effort is required to pursue the common objectives of the company.

Participants

The study was conducted in a university accredited by the Association to Advance Collegiate Schools of Business (AACSB). The participants were senior graduate students. The students were divided into 5-participant-groups (companies). We explored three semesters: (1) the spring 2005 semester, consisting of 18 companies; (2) the summer 2005 semester – 20 companies; and (3) the spring 2006 semester – 20 companies. In the fall semester of 2005 we experienced only 9 groups, and therefore, decided not to include that semester in this research.

Hypotheses

This study aims to measure the effectiveness of the developed DSS. For that, we measure the participants' perceived benefits from using a DSS, variables related to DSS use, user satisfaction, and success.

As we use the business game as a tool for measuring MIS and DSS, we follow hypotheses examined by Ein-Dor and Segev (1984) and Ben-Zvi (2007). The first hypothesis in this study relates variables in DSS studies to DSS effectiveness.

Many researchers in MIS have studied the effect of various variables on the success and failure of MIS (e.g., Bharati and Chaudhury, 2004; Reinig, 2003). Common measured criteria of DSS success include system's reliability and flexibility (Srinivasan, 1985), the ability of a system to support decision-making and problem-solving activities (Garrity and Sanders, 1998), decision confidence (Goslar et al., 1986), use and user satisfaction (Baroudi et al., 1986; DeLone and McLean, 2003). In this study we examine the following DSS success variables: usefulness, user satisfaction, system contribution to functional area and company success, own use and colleague use.

Association of management with DSS (i.e., active involvement of management) has long been considered as contributing to, or perhaps even essential to, the success of DSS. In this study, association with DSS is evaluated on the basis of the students' familiarity with their company's system and their participation in defining it.

The first hypothesis relates to both individual and company level:

Hypothesis 1: The measures of success and active involvement present high and significant correlation between them.

The second hypothesis in this study relates DSS effectiveness variables to company performance:

Hypothesis 2: The measures of DSS success and active involvement are highly correlated with company performance.

As each company functions as a distinct entity in the game, we also examine the dissimilarity between the companies:

Hypothesis 3: Company differentiation in DSS: Variance between the companies is significantly different from the variance within the companies.

Procedures

At the end of each semester, after the last set of decisions had been made, each group was required to present its DSS in class and to submit a report consisting of: (1) a definition of the scope of the system; (2) a decision analysis; (3) a system design; and (4) a discussion of the contribution of the system in achieving the group's objectives during the game. At that same meeting, each of the students was asked to complete a short individual questionnaire on the DSS assignment (see the appendix for the text of the questionnaire).

RESEARCH FINDINGS

Developed Systems

Two-thirds of the companies in all three semesters nominated a Chief Information Officer (CIO). All companies reported developing an information system but none of the companies reported major modifications during the semester. We present an example of the systems developed in the spring semester of 2005. Eighteen companies were created in that semester, most of which developed a Microsoft Excel spreadsheet-based DSS. The major characteristics of the systems developed are exhibited in Table 1.

For this study, the most relevant aspect of Table 1 is the extent to which the companies differed on their systems. Companies, in all three semesters, adopted different application areas with models including various statistical analyses, spreadsheets—and even linear regressions. Only 3 companies (5% of all companies) employed any type of package software. Thirty five companies developed complicated data analysis tools (mostly statistical or engineering analyses) for their systems (60% of all companies). Only 19 companies developed graphic outputs (about a third of all companies), while the remaining 39 did not. Finally, the sophistication and complexity of the models employed varied significantly from simple spreadsheet analyses (companies 5 and 7 in the spring semester of 2005) to a complex linear model (company 4 in that same semester). While it cannot be claimed that the distribution of attributes of systems exactly measures that in the real world, the degree of diversity of systems developed, based on existing tools, does appear to be quite real.

Co.	System Area	Nature of System	Data Analysis	Graphics
1	Production, Finance, Market Analysis	Electronic Sheet	Yes	No
2	R&D, Production, Finance, Marketing	Electronic Sheet	No	Yes
3	Production, Finance, Market Analysis	Electronic Sheet	Yes	No
4	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet, Regressions	Yes	No
5	Production, Finance	Electronic Sheet	No	No
6	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet	Yes	No
7	Production, Finance	Electronic Sheet	No	No
8	R&D, Production, Finance, Marketing, Market Analysis	Electronic Sheet	Yes	No
9	Production, Finance	Electronic Sheet	No	No
10	Production, Finance, Marketing	Electronic Sheet	No	No
11	R&D, Production, Finance, Marketing	Electronic Sheet	No	No
12	R&D, Production, Finance, Market Analysis	Electronic Sheet, Regressions	Yes	No
13	R&D, Production, Finance	Electronic Sheet	No	Yes
14	Marketing, Market Analysis	Electronic Sheet, Regressions	Yes	No
15	Finance, Marketing, Market Analysis	Electronic Sheet	Yes	Yes
16	Production, Marketing	Electronic Sheet	Yes	Yes
17	Production, Finance	Easy Plan, Electronic Sheet	No	No
18	Finance, Marketing	Electronic Sheet	No	No

Table 1. Characteristics of Systems Developed by Companies in the Spring Semester of 2005.

Figures 1 and 2 present a sample of those systems. Figure 1 demonstrates the market analysis conducted by company 1 in the 6th played period of the spring semester of 2005. Part I of Figure 1 presents an analysis of the US market. Company 1 mainly operated in the US market and therefore, a full analysis of prices, models, market share and inventory was required. Part II analyzes the company's inventory in the US market. Part III exhibits an aggregated analysis of all companies' world-wide.

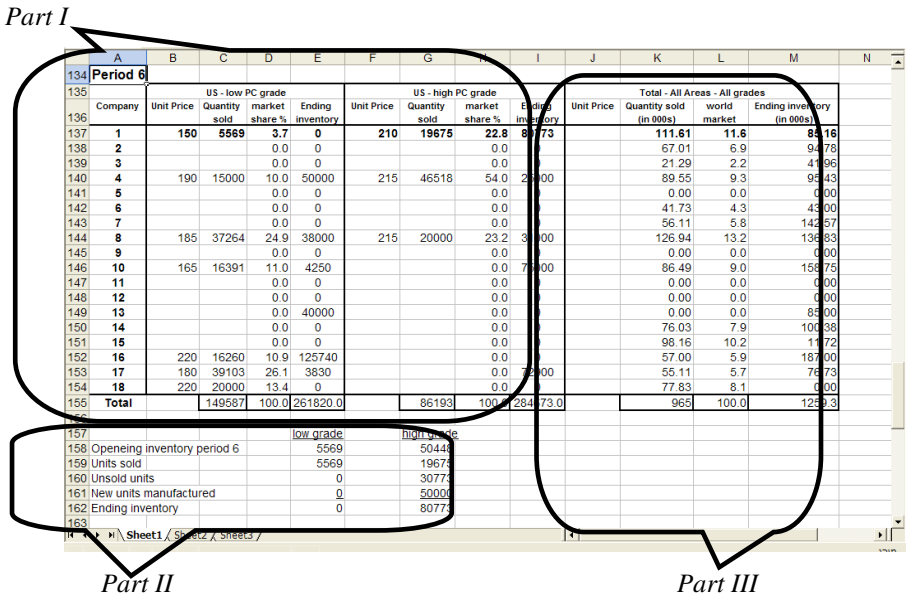

Figure 1. A Sample of DSS Developed by Company 1in the Spring Semester of 2005.

Figure 2 illustrates a DSS use made by company 15. It shows the total sales (in units) in all three markets: the US, the EU and Brazil. Company 15 also affixed a linear trend line to each market, which is highly correlated with each market total sales ($R^2 \cong 0.92$). These graphs helped Company 15 in making predictions of future sales in each market.

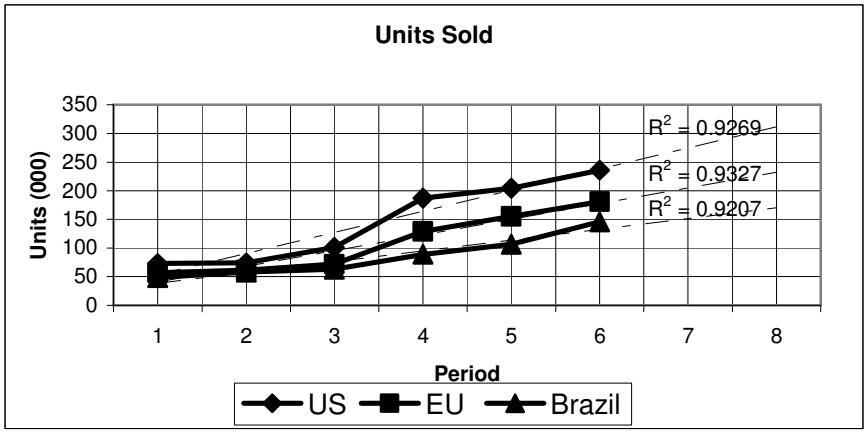

Figure 2. A sample of Graphical Market Analysis made by Company 15.

Analysis

In order to enhance the validity our results, we compared them to previous findings reported by Ein-Dor and Segev (1984) and Ben-Zvi (2007). The analysis of the data relates both to individuals and to companies. Company data in this study aggregate the individual data of the company's members, and is conducted in order to determine whether the participants in the game coalesce into distinguishable companies.

First, the customary variable in DSS studies, degree of success, is analyzed. Next, company performance is analyzed with regard to the developed DSS. Finally, we discuss company differentiation. The internal consistency among the items, Cronbach's alpha (Cronbach, 1951), is 0.8345 at the individual level and 0.8532 at the company level. Means and variance of responses to the first 10 questions are exhibited in Table 2.

Variable	Individuals (n=290)		Companies (n=58)	
	Mean	S.D.	Mean	S.D.
Familiarity	5.62	1.35	5.55	0.82
Usefulness	5.52	1.12	5.42	0.91
Own use	5.29	1.52	5.06	0.88
Contribution to functional area	5.33	1.48	4.99	1.04
User satisfaction	5.42	1.45	5.02	1.27
Use by colleagues	4.89	1.21	4.87	0.81
Contribution to company success	5.45	1.39	5.04	1.18
Participation	4.56	1.91	4.57	1.14
Disturbance	2.88	1.98	2.87	0.78
Met expectations	5.21	1.73	4.59	1.41

Table 2. Means and Standard Deviations (S.D.) of Responses for Individual and Companies.

Company Performance Analysis

We now investigate company performance versus the measured variables. In all three studied semesters, company performance was measured by the companies' accumulated retained earnings (accumulated profits). The results indicate that five variables are strongly related to the company's performance: system's usefulness, user satisfaction, contribution of the DSS to the diverse functional areas and to the entire company success and whether the DSS met its expectations. It seems that the students where rather satisfied with the systems that they had developed. However, the better the developed system was able to achieve the users' goals, the better the company's performance in the game. Nevertheless, the two variables related to the participation of users in defining the DSS present negative correlation with the company's performance. It seems that added involvement in developing the DSS impairs performance.

Furthermore, we measured a correlation of 0.29 between the number of functions the DSS cover (e.g., production, finance, market analysis) and the companies' performance. There is also a correlation of 0.35 and 0.05 between a company's performance and its use of data analysis tools and graphics, respectively.

To summarize, it can be claimed that a successful DSS in the eyes of the users is related to better company performance in the game. However, investing a lot of human resources in developing a complicated system that makes use of several features does not necessarily guarantee enhanced company performance.

Company Differentiation

Ein-Dor and Segev (1978) indicated that the organizational and external environments of information systems were recognized as one of the factors impacting the success and failure of information systems. Those environmental factors are usually uncontrollable and as a result, they invariably cloud the meaning of data collected in trans-organizational comparisons of DSS.

One of greatest advantages of the business game is the common and controlled external environment it provides for all participating companies. Despite the identity of initial conditions, significant differences in DSS emerged by the end of the game in each semester. Table 3 exhibits the analysis of variance, by all 58 companies, for each variable in the questionnaire. The data indicate that, for 5 of the 10 variables, the variance between companies is significantly different (at the .05 level) from the variance within companies.

For two measures of success, the level of performance and the user satisfaction, results exhibit highly significant F values, indicating that the variance of responses within companies are appreciably smaller than those between companies. The third measure of success, the system's use, does not exhibit low variance of responses within companies.

Variable	F value	Sig. of F
Familiarity	1.014	0.478
Usefulness	2.049	0.029
Own use	1.263	0.262
Contribution to functional area	2.037	0.030
User satisfaction	3.541	0.000
Use by colleagues	0.861	0.622
Contribution to company success	3.491	0.000
Participation	0.918	0.561
Disturbance	0.349	0.991
Met expectations	3.769	0.000

Table 3. Analysis of Variance of All Variables by Companies (n=58).

DISCUSSION AND CONCLUSIONS

Simulated companies were formed in this study. Although the general environment was mutual to all participants, the companies became differentiated. Each assumed considerably different strategy, different operating decisions, and a different approach to DSS. Leaving to the companies the decision on areas of DSS development resulted in a variety of applications, utilizing an array of models, programs, and modes of operation. It appears that these companies reflect most real life business approaches to DSS.

In addition to the creation of simulated companies with differentiated approach to DSS, this study also tested three hypotheses. All three hypotheses were mostly confirmed, replicating a number of previous findings. Overall, results at both the individual participant and the company levels underscore the validity of conclusions derived from the simulation to real businesses, notwithstanding the relatively small sample size. Hence, the business game may be used as a vehicle for implementation of DSS.

Moreover, the game provides an environment of decision-making under uncertainty using the aid of DSS. As it continuously provides feedback from task performance, the game allows students experience the need of relevant information to improve on performance. The game also encourages students to use theoretical concepts learnt through formal lessons and applying them to support their problem solving activities. In addition, the game can help students achieve not only technical capability, but also a managerial perspective of problems. As more and more businesses install enterprise resource planning (ERP) systems, they will be able to analyze their valuable data. The ultimate result will be more successful MIS and DSS systems in the real world.

Furthermore, nowadays, even the frequently used spreadsheets are sufficient tools to create extremely powerful and useful DSS. Employing the business game method provides a strategic opportunity to provide students with more practical and relevant DSS context and consequently, enhance their applicability in real life applications, not restricted only to the information systems field. In the examined game, most of the companies developed a spreadsheet-based DSS. Although some may regard those spreadsheets as too simplified DSS, our study showed that complicated systems do not guarantee better company performance. Moreover, spreadsheets offer some substantial advantages: Many students today are familiar with spreadsheets tools so they can quickly employ them for the development of a DSS. Spreadsheets also allow students a dynamic data updating and an easy development of data visualization. Also, spreadsheets today hold some powerful data analysis tools (e.g., Analysis ToolPak in Excel).

However, although feedback from students is favourable, and the game is sufficiently complex to provide challenges and a realistic simulation of decision making, no business game can seize all aspects of information systems. As the game decisions are more simplistic than those of the "real-world", the DSS required to support the decisions are less complicated than those in reality. Therefore, there is a need to determine how business games can be applied in studying various aspects of the DSS domain: use and performance can be easily measured and evaluated, but the cost/benefit or return of investment of a specific information system is as vague in the game as it is in real life.

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APPENDIX

Questionnaire – Decision Support Systems Report

The following questions relate to the Decision Support System, which was developed in your company. Please indicate your answers:

		Not at all	To a very small degree	To a small degree	To a degree	To a large degree	To a very large degree	Maximally
1.	I am familiar with the system developed in the company	1	2	3	4	5	6	7
2.	The system is useful for decision making	1	2	3	4	5	6	7
3.	I personally used the system for making decisions in my role in the company	1	2	3	4	5	6	7
4.	The system contributed to the company's performance in my functional area	1	2	3	4	5	6	7
5.	I am satisfied with the system	1	2	3	4	5	6	7
6.	My colleagues in the company used the system for decision making	1	2	3	4	5	6	7
7.	The system contributed to the company's success	1	2	3	4	5	6	7
8.	I participated in defining the system	1	2	3	4	5	6	7
9.	Developing the system interfered with my functional role in the company	1	2	3	4	5	6	7
10.	The system's benefits met my expectations	1	2	3	4	5	6	7